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Acute stenting and thromboaspiration in basilar artery occlusions due to embolism from the dominating vertebral artery

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Abstract Intra-arterial thrombolysis (IAT) is the only treatment that has demonstrated benefit in patients with acute basilar artery occlusions (ABAO). IAT may be difficult to perform when access to the occluded basilar artery (BA) is prevented by pathology of the vertebral arteries (VA). We report on two patients with ABAO due to embolism from the dominating VA. Catheter navigation through the occluded VA and thromboaspiration enabled access to the BA. Thromboaspiration alone or in addition to IAT resulted in a complete recanalization of the BA and a favorable clinical outcome. A stent was deployed at the site of the stenosis in the VA either prior to or immediately after BA recanalization.

Keywords Basilar artery · Stenting · Stroke · Thromboaspiration · Thrombolysis

Introduction

The therapeutic options in patients with acute basilar artery occlusion (ABAO) are limited. Standard medical treatment with platelet inhibitors or anticoagulation usually fails to improve prognosis. To date, local intra-arterial thrombolytic therapy is the only life-saving treatment that has demonstrated benefit with regard to mortality and outcome, although it has not been proven yet in a randomized trial [1, 2, 3, 4, 5]. Despite encouraging results, intra-arterial thrombolysis (IAT) remains underutilized for treatment of ABAO. The lack of clear evidence-based guidelines and the rapidly progressing clinical deterioration are the main reasons to withhold treatment.

Due to anatomical reasons, local IAT may be problematic, e.g., if a bilateral occlusion of the vertebral arteries or an occlusion of one vertebral artery (VA) and a hypoplasia of the other one is found. This "upstream" hindrance prevents access and local delivery of the fibrinolytic agent to the clot in the basilar artery (BA). Catheter navigation through the occluded VA followed by stent deployment and thromboaspiration might therefore be an option to give these patients thrombolytic treatment. The present study aimed to describe the technical aspects of this treatment in patients with ABAO due to embolism from the dominating VA.

Methods

From December 1992 to December 2003, 36 patients with ABAO underwent endovascular revascularization

treatment including IAT at the university hospital of Bern. Thirty-two were described in earlier reports [5, 6]. Four patients had a high-grade stenosis of the dominating VA that necessitated a percutaneous transluminal angioplasty (PTA). In two, a balloon dilation of the VA stenosis was performed in order to access the occluded BA. Endovascular treatment of the remaining two patients included stent deployment at the site of the VA stenosis, thromboaspiration, and IAT (in one patient). Stroke workup, technical aspects of the endovascular treatment, clinical, and radiological outcome of these patients are presented below.

Patient 1

A 51-year-old man with a prior history of cigarette smoking presented with somnolence (GCS 12), upbeat nystagmus, severe dysarthria, bilateral facial weakness, hypesthesia over the right side of the face, and left-sided hemiparesis. Symptoms had a sudden onset without any prodromal signs. After a clinical examination by the family physician, the patient was referred to the nearest community hospital. The computed tomography (CT) revealed a hyperdense basilar artery; there were no early signs of cerebral ischemia or hyperdense lesions suggesting an intracranial hemorrhage. The patient was considered a possible candidate for thrombolysis and was transferred immediately to our university-based stroke center. He arrived at our institution about 3 h after symptom onset. Magnetic resonance imaging (MRI) demonstrated absence of flow in both vertebral arteries, proximal BA occlusion, and intraluminal thrombus within the distal BA (Fig. 1A). Diffusion-weighted MRI (DWI) revealed signal increase in the territory of the left superior cerebellar artery (SCA) (Fig. 1B). Perfusion-weighted MRI (PWI) showed hypoperfusion in both cerebellar hemispheres and over the whole brainstem.

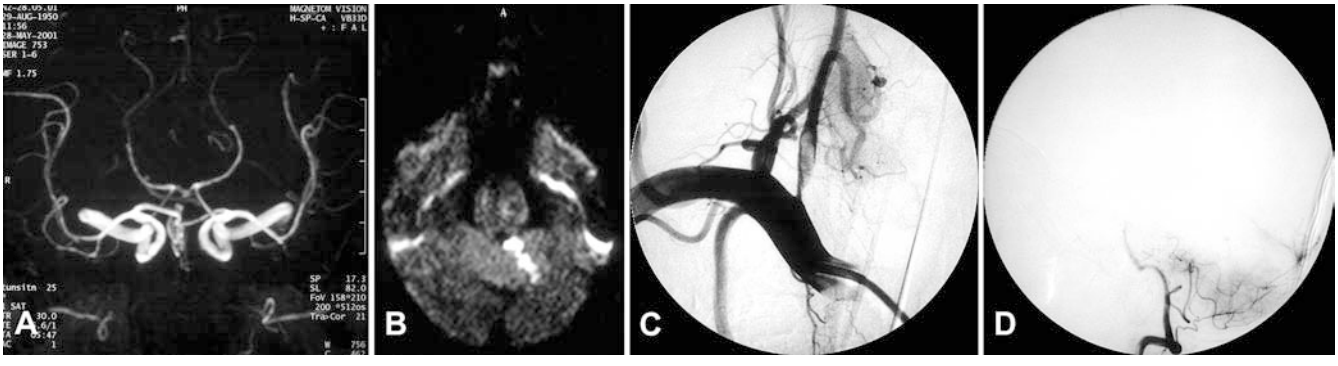

Fig. 1A–D Patient 1: diagnostic workup. Time-of-flight magnetic resonance (MR) angiography (TOF-MRA) reveals absence of flow in both vertebral arteries (VA) and the basilar artery (BA) (**A**). Diffusion-weighted MRI (DWI) shows acute infarction in the territory of the left superior cerebellar artery (**B**). Digital subtraction angiography (DSA) of the right subclavian artery reveals an intraluminal thrombus in the proximal segment of the right dominating VA adjacent to a high-grade stenosis at the origin (**C**). Late phase of the right VA DSA confirms a proximal BA occlusion without significant posterior inferior cerebellar artery (PICA) collateral flow (**D**)

Technical aspects of the endovascular treatment

Three hours and 40 min after stroke onset, the patient was transferred to the angiography room. In a first step, catheterization of the left subclavian artery (SA) revealed a hypoplastic left VA, which was truncated just distally from the origin of the posterior inferior cerebellar artery (PICA). In a next step, examination of both carotid arteries and their branches was performed, which was normal. Both left and right carotid angiography revealed a crossover flow through the posterior communicating artery into the posterior cerebral artery, the top of the BA, and the right SCA. The diagnostic cerebral angiography ended with the catheterization of the right SA. It demonstrated a high-grade stenosis at the origin of the VA (Fig. 1C). The filiform residual lumen and the shape of the opacification defect (*arrow*) suggested a thrombus at the site of the stenosis. The distal right VA demonstrated a delayed filling that ended with the proximal BA occlusion (Fig. 1D).

The decision for endovascular treatment including IAT was taken, considering the time from symptom onset within the therapeutic window, the PWI/DWI mismatch, and the lack of severe unconsciousness. At this point, general anesthesia was administered, and the patient underwent a full heparinization (activated clotting time, >250 s).

A 7-French guide catheter (Boston Scientific) was selectively introduced into the origin of the right VA proximally from the stenosis. Guided by biplane roadmap, a Fast-Tracker-18 catheter and a long 14-guidewire were carefully advanced through the stenosis into the distal VA. The microcatheter was then retracted and a 3.5/18 Tetra Megalink stent (Guidant) was deployed at

the site of the stenosis (Fig. 2A). A control angiogram revealed a small residual thrombus at the distal end of the stent (Fig. 2B). Afterward, the microcatheter was carefully introduced into the basilar artery, and 500,000 U of urokinase (UK) were infused. The effect was a weak anterograde BA flow that ended proximally from the origin of the AICA. Finally, a Tracker-38 catheter with a length of 120 cm was introduced through the 7-French guide catheter into the proximal BA. While keeping the catheter under negative pressure, it was carefully advanced to the site of the occlusion. Thrombotic material could be aspirated using a 20 ml syringe. A negative pressure was maintained also in the guiding catheter, thus preventing distal thrombus migration. Thromboaspiration through both catheters resulted in a complete recanalization of the BA (Fig. 2C).

Clinical and radiological outcome

The patient underwent extubation 4 h after the endovascular treatment. MR angiography performed the next day confirmed the correct position of the stent and the patency of the right VA and the BA (Fig. 3A). DWI revealed a small increase of the hyperintense lesion in the vermis and in the left cerebellar hemisphere, corresponding with T2 signal increase (Fig. 3B). The neurological examination at hospital discharge was normal except for mild dysarthria and left-sided hypesthesia. ASA 250 mg/day and clopidogrel 75 mg/day were given for secondary prevention of cerebral ischemic events.

Nevertheless, repeated vertiginous symptoms over the following 3 months necessitated a re-hospitalization. The neurological status was unchanged; MRI examination found no recent ischemic lesions. Cerebral angiography and ultrasound examination of the brain-supplying arteries revealed a low-grade restenosis within the stent in the right VA. A lipid-lowering agent (pravastatin 20 mg/day) was introduced in addition to the therapy with platelet inhibitors. Five months later, the patient's neurological status went back to normal, the patient had no complaints, and the restenosis grade did not change.

Patient 2

A 42-year-old woman with a blank medical history experienced a sudden onset of vertigo, vomiting, and diplopia. The patient did not seek medical help at first,

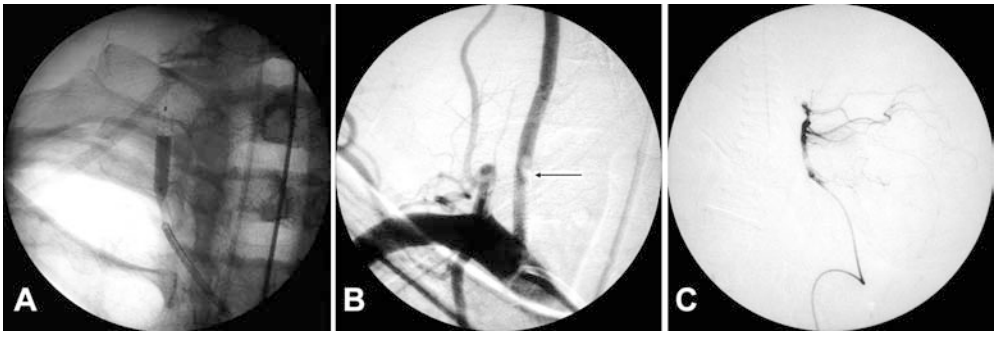

Fig. 2A–C Patient 1: Endovascular treatment. Placement of the balloon-expandable stent at the origin of the right vertebral artery (VA) (**A**). Small residual thrombus at the distal end of the stent (**B**). Digital subtraction angiography (DSA) after thromboaspiration with the tip of the Tracker-38 catheter in the mid-basilar region (lateral view) (**C**)

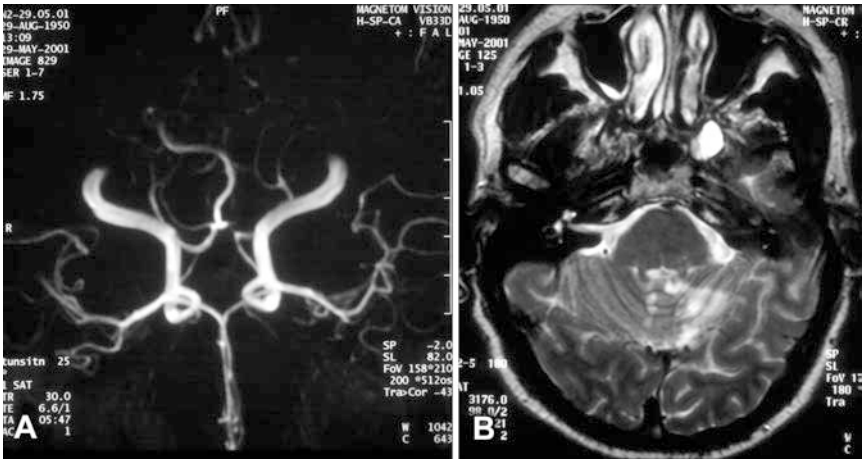

Fig. 3A–B Patient 1: Radiological follow-up. Time-of-flight magnetic resonance (MR) angiography (TOF-MRA) performed on the following day demonstrates normal flow in the dominating vertebral artery (VA) and the basilar artery (BA) (**A**). T2-weghted MRI (**B**) shows a subtle increase of the infarction volume in the territory of the superior cerebellar artery (SCA)

and presented at the stroke center 12 h later when the vigilance began to deteriorate. Clinical examination revealed a skew deviation and a spontaneous nystagmus of the abducted eye bulb, right-sided facial paresis, and a bilateral ataxia. The T2-weighted MRI was normal. DWI and ADC maps demonstrated lesions within the pons and the mesencephalon; magnetic resonance angiography (MRA) revealed a proximal occlusion of the right VA as well as a BA occlusion. The progressing clinical deterioration necessitated the administration of general anesthesia.

Technical aspects of the endovascular treatment

The angiographic findings were similar to those in patient 1: thrombus in the dominating right VA causing a hemodynamically total occlusion of the vessel (Fig. 4A), crossover flow through the circle of Willis into both posterior cerebral arteries and the tip of the BA (Fig. 4B), and proximal occlusion of the BA (Fig. 4C). In contrast to patient 1, there was a collateral blood flow from the left VA and the left PICA into the superior branches of the BA (Fig. 4C). The location of the right VA occlusion (distally from the origin, V1/V2-junction) was suggestive for spontaneous dissection.

Endovascular treatment aimed to recanalize the dominating right VA while preserving blood flow through the nondominating left VA during the procedure. A 7-French guide catheter (Boston Scientific) was introduced into the stump of the right VA (Fig. 5A,B). While performing a continuous aspiration, the catheter was carefully navigated through the occlusion. A Tracker-38-catheter (length 120 cm) was then advanced to the proximal site of the BA occlusion through the guider. Repeated thromboaspiration both through the Tracker-38 and the 7-French guider resulted in complete recanalization of the BA. Due to the considerable delay of 17 h 20 min since symptom onset, pharmacological IAT could not be attempted.

Control angiogram of the left VA confirmed the recanalization of the BA (Fig. 5C) Selective angiography of the right VA revealed an extended dissection of the vessel (Fig. 5D,E). Implantation of two Easy Wall stents (Boston Scientific; width 5 mm, length 20 mm and 30 mm) followed (Fig. 5F,G,H).

Clinical and radiological outcome

The patient underwent extubation the next day. Two weeks later, she was discharged from the stroke center and was referred to a rehabilitation hospital. At discharge, the initially recorded internuclear ophthalmoparesis (INO) and the bilateral ataxia persisted. ASA 100 mg/day and clopidogrel 75 mg/day were given for secondary prevention of cerebral ischemic events. MRA and ultrasound follow-up examinations confirmed the patency of right vertebral and the BA. In a control MRI study, the extent of the DWI lesion remained unchanged. The bilateral ataxia significantly improved during the rehabilitation process resulting in a modified Rankin scale score of 2 at the 3-month control. A transcranial Doppler (TCD) examination performed 3 months after the stroke onset revealed normal blood flow in the BA.

Discussion

Acute BA occlusion is a devastating condition that is usually associated with a poor clinical outcome. Mortality approaches 90% if conventional antithrombotic therapy is used [1]. Fibrinolytic therapy may improve prognosis and reduce mortality [1, 3, 4, 5, 7]. Several series reported 25–64% survival rates and 20–35% favorable clinical outcome after IAT [1, 3, 4, 5, 7, 8, 9].

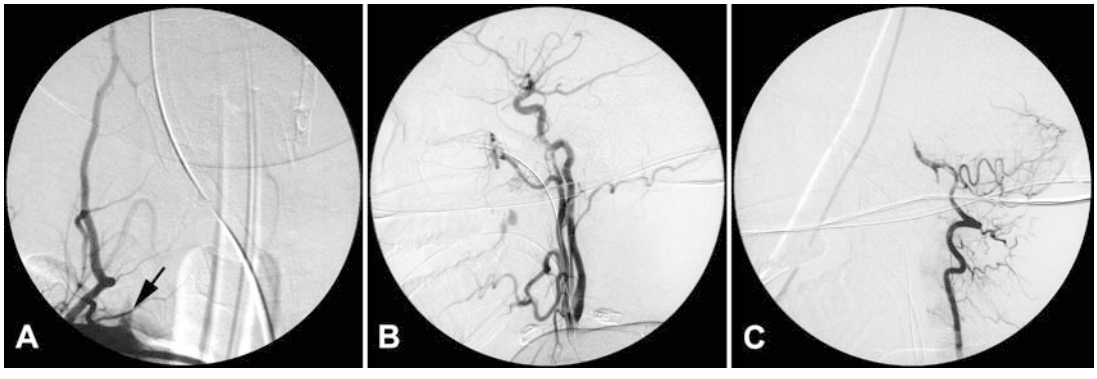

Fig. 4A–C Patient 2: Diagnostic workup. Digital subtraction angiography (DSA) of the right subclavian artery reveals a short vertebral artery (VA) stump (*arrow*) proximal to the normal ascending cervical artery (**A**). DSA of the right common carotid artery demonstrates crossflow from the internal carotid artery to the posterior cerebral artery and the tip of the basilar artery (BA) (**B**). DSA of the left nondominating VA confirms the proximal BA occlusion. Subtle collateral flow from the left posterior inferior cerebellar artery (PICA) to the superior branches of the BA is seen (**C**)

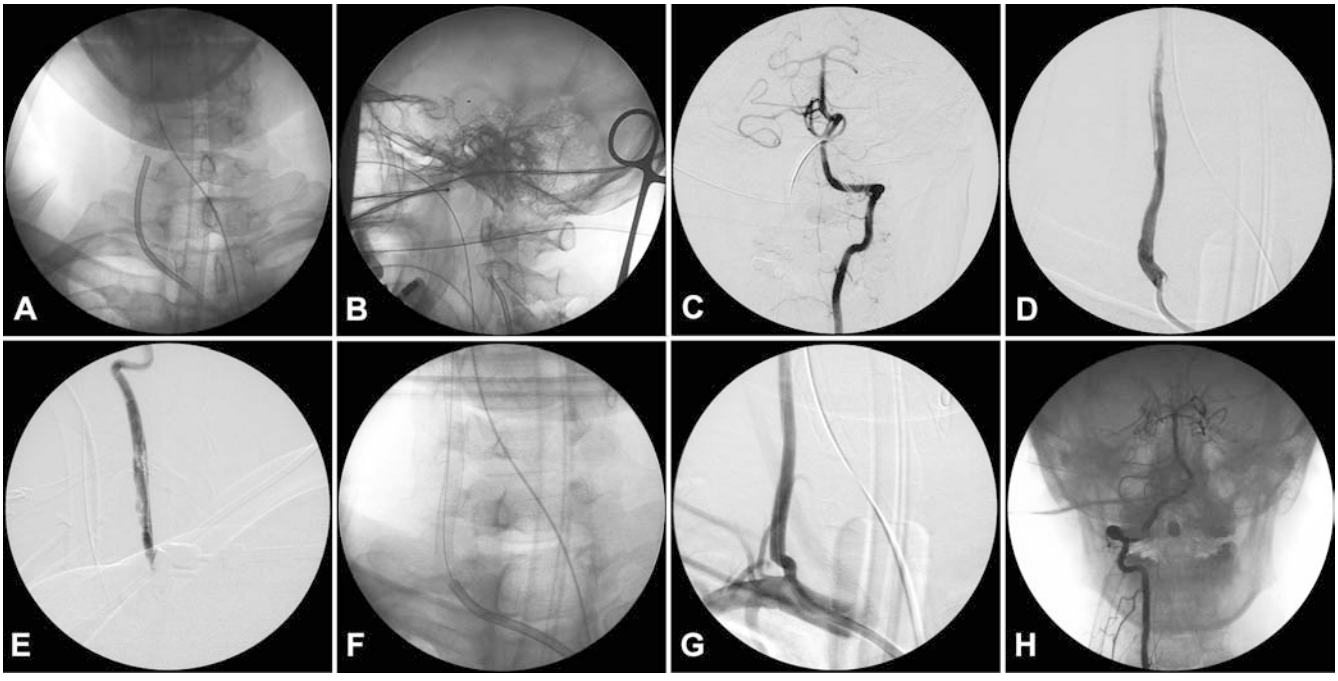

Fig. 5A–H Patient 2: Endovascular treatment. The tip of the 7-French guide catheter in the proximal (**A**) and distal segment of the right vertebral artery (VA) during thromboaspiration (**B**). The tip of the Tracker-38 catheter can be clearly seen at the top of the recanalized basilar artery (BA) after repeated thromboaspiration through the Tracker-38 and the 7-French guide catheters. Digital subtraction angiography (DSA) of the left VA in Towne projection confirms revascularization of the BA (**C**). Selective angiography of the right VA demonstrates extended dissection of the proximal (**D**) and distal (**E**) cervical segment of the artery. Implantation of two overlapping Easy Wall stents: anterior-posterior view (**F**), DSA of the right subclavian artery (**G**), distal segment of the right VA (**H**)

Among all factors related to the prognosis, recanalization seems to be the most important. The first large observation of patients with ABAO and IAT included 43 patients [1]. In this series, all patients without recanalization died, while 14 of 19 patients displaying recanalization survived. Later on, this observation was reproduced by several studies using various thrombolytic agents and time windows [3, 5, 7, 8, 10]. Short time delay from symptom onset to IAT rendered recanalization of the occluded BA more likely [10]. Therefore, early initiation of thrombolysis should be attempted whenever possible. Endovascular interventions in the vertebrobasilar circulation are challenging, because the catheter must be inserted through tortuous vessels of small caliber. Early initiation of IAT is even more problematic when a high-grade stenosis of the dominating VA coincides with a hypoplasia of the contralateral VA. To reach the clot in the BA, a revascularization of the dominating VA by means of thromboaspiration and PTA should precede the IAT.

Thromboaspiration is a common approach in peripheral interventions [11]. In occlusions of the cerebral vessels, it is rarely attempted due to the risk of distal thrombus migration. However, a few case reports demonstrated encouraging results, especially with fresh and nonadhesive thrombi [12, 13]. This was the situation with our second patient who had a spontaneous VA dissection. Thrombus aspiration requires favorable anatomical conditions and the use of large catheters in order to achieve the highest possible negative pressure.

Thrombi occurring on the surface of ulcerated atherosclerotic plaques are usually adhesive. Stent implantation at the site of the stenosis is the treatment of choice when passage through the stenosis succeeds. Thromboaspiration may follow stent implantation if clot disruption and distal migration during stent delivery are suspected. A faster approach to the occluded BA could be catheterization of the nondominating VA if the anatomical conditions allow it. Even then, we do not recommend recanalization of the BA before the source of the embolism in the dominating VA has been eliminated.

In the first of our cases, recanalization of the VA could be performed within the therapeutic time window. Once the clot in the BA was reached, we started infusion of 500 000 IU urokinase. However, recanalization of the BA was incomplete with pharmacological thrombolysis. Thrombus aspiration through a Tracker-38 catheter resulted in complete recanalization of the BA. In the second patient, the clot site in the BA was reached 17 h 20 min after onset of symptoms. Therefore, we decided

to perform mechanical thrombus extraction that ended with complete recanalization of the BA.

Embolic occlusions of the BA are thought to recanalize more readily [7, 10, 14]. In keeping with these findings, we achieved a complete recanalization in our patients with presumed embolic occlusion of the BA. Pathoanatomic and clinical studies suggest that embolic occlusions occur in the distal portion of the BA, while occlusions affecting the vertebrobasilar junction up to the mid-basilar portion of the BA are atherothrombotic [3, 7, 8, 10, 15, 16, 17]. However, arterial embolism from the dominating VA was the most probable etiology in our patients despite proximal localization of the BA occlusion. Seemingly, localization alone is not sufficient to determine the etiology of the occlusion, and a comprehensive diagnostic workup is needed.

To summarize, endovascular therapy may be attempted in ABAO due to arterial embolism from the VA. Thromboaspiration and stent implantation are valuable options alone or in addition to pharmacological thrombolysis. Thromboaspiration might render favorable clinical outcomes in patients treated beyond the time window for pharmacological thrombolysis. A comprehensive diagnostic workup is needed to identify the best candidates for this treatment.

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